

THE HISTORY OF SCIENCE—AN INTERPRETATION

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IN the recent discussion of the ways and means of making more efficient use of science in educational work, one suggestion keeps coming repeatedly to the front—perhaps more frequently than any other. It is this: That the history of science be made more prominent in the course.

This suggestion has been made from a number of different points of view. For example, some claim that the stories of the lives of the heroes of science furnish powerful stimuli toward arousing interest in and enthusiasm for the study of science. Others urge that the history of inventions may be used to great advantage in linking work in science with social and economic life, thus adding a touch of human life to an otherwise rather abstract and impersonal subject. Still others hold that scientific concepts can not be clearly formed without tracing them from their origin through their development to their present condition.

The importance of recognizing that science is not ready-made, fixed and finished in form and matter; the delight that young people feel when they are shown that the field is open before them, so that they too have a chance to help in the building up of science; the pleasure of knowing that he who works in science is dealing with a growing thing—all of which may be obtained from a study of the history of science—are all put forth as reasons for our paying attention to this side of our work. To one who thinks over these various suggestions, it must appear that they are not independent of one another. Hence, because of the growing importance of this matter of history of science, it becomes of interest to see if a more general justification for its introduction can not be found—one that includes all the others as special cases, and at the same time points out the way in which this history should be handled to enable it to produce the most valuable results. If we would attempt to do this, we must first agree on what we mean by history, and what by science; since each of these words covers such a multitude of things that its meaning is not sufficiently definite for our purpose.

I. The history whose study lends power to the teaching of science is, naturally, not the thing that is popularly known as history; namely, political history. It is evidently of small interest to science

to know to which royal family the king at any given period belongs; nor is science particularly concerned with the list and the peculiarities of the wives of Henry VIII. Science does not even care tremendously whether Marie Antoinette spent her summers at Versailles or at Medicine Hat; nor yet whether the jewels of the mother of the Gracchi were real diamonds or only paste. This sort of information, which seems to be of paramount importance in what popularly passes under the name of history, has no part or place in the type of history in which science is interested.

Just exception might be taken to any attempt on the part of a specialist in science to define what constitutes the right sort of history—even though it be history of science. Fortunately, however, some specialists in history have given us a definition of history to which the scientist may give a hearty consent. Traces of this interpretation of history may be found in a number of historical works of the past half century, but it has only recently found extended expression in the writings of Carl Lamprecht and his followers. A good summary of the philosophy of this school of historians was given by Professor Lamprecht in a course of lectures delivered by him in 1904 both in St. Louis and in New York. These lectures have been published in English under the title "What is History?"

For science the most important points in the doctrines of this Leipzig school seem to be these: (1) That history—real history—consists in the portrayal of a series of culture epochs; (2) that the character of these culture epochs is determined by the higher spiritual or psychic attitude of the more gifted of the people, and not by the whims and idiosyncrasies of a line of sovereigns; (3) that the most telling criterion of the psychic attitude of a people at a given epoch is found in the productions of their creative imagination. Hence, if we would understand the nature of the culture of any people at a given epoch, and trace the mechanism of its changes to the next epoch, we must study first of all the products of their creative imagination, *i. e.*, their art, their poetry, their philosophy, and their science. Important, but of secondary importance, are the political, social and economic conditions. In other words, the psychic character of any nation at any epoch is determined by the spiritual attitude of the best people; and this condition is expressed more directly in the works of their creative imagination, and less directly in their political, social and economic conditions.

To sum up this first point, then, we may say that the sort of history needed by science is a portrayal of culture epochs, their character having been determined by a study of the works of the creative imagination of the best people of the time; and hence the importance of the history of science is derived from the fact that science is one of the

productions of the creative imagination, and therefore the study of its history, when properly conducted, should shed immediate light on the problem of determining the nature of the psychic condition of a people at any epoch, *i. e.*, the character of the culture epoch, and of discovering the mechanism of the change from that epoch to the next.

II. But, supposing this to have been accomplished—which has not yet by any means been done—what good will result? Why should we care to gain an insight into the psychic development of a nation?

One immediate consequence of this sort of historical study would be the much-desired humanizing of science; for we should be compelled to recognize the various ways in which science has cooperated with the other phases of human activity in bringing us into our present condition. Still another fruitful consequence would be the gradual extinction of the pernicious notion that scientific conclusions are final—that the *ipse dixit* of science permanently settles all controversy. Other specific benefits might be mentioned: but in this case also all roads lead to Rome, since the central idea of all the reasons for the study of the sort of history that has just been defined is the idea of the analogy or correspondence which exists between the development of a nation and that of each individual of that nation. It is the idea expressed in the *Gliedganzen* of Froebel, in the parallelism between the ontogenetic and the phylogenetic series of Baldwin, etc. It is the idea expressed by Lamprecht when he says: "History in itself is nothing more than applied psychology."^{1a} According to this idea we must study the past evolution of science in a people or in a type of civilization in order to understand the evolution of science in the present individuals of that people or of that type of civilization: and conversely, the psychological study of the growth of scientific concepts in the individual sheds light on the scientific growth of the nation.

The meaning and the importance of this idea, not only to teachers of science but to teachers generally, have not yet become fully apparent. Some go so far as to ridicule it. Thus in a very able address on the "Order and Development of Studies suited to Each Stage," Superintendent Wm. E. Chancellor, of Washington, D. C., reaches the following conclusion:¹

In this presentation, I have absolutely rejected two familiar theories; that the child must pass through the history of the race, and that he must be prepared directly for participation in the affairs of the modern world. . . . And I have said in terms as unequivocal as they are brief that, to my thinking, as I view the external world of reality and the real world of the soul, we shall find our solution in a genetic psychology that reveals the processes and stages, the functions and the interests, the motives and the ideals, and the principles of the soul as it journeys and sojourns from birth to death.

¹ Report of the Department of Superintendence, 1907, p. 80.

^{1a} "What is History?" p. 29.

He does not seem to see that psychology will become more complete and more able to furnish the solution so earnestly desired by all, the more it is studied as applied psychology in history as well as applied psychology in the individual. The two are mutually complementary; by neither method alone can we hope to reach as deep an insight into the meaning of history and the growth of the individual as we can if we use both methods, and continue to work till the results obtained from the two are in substantial accord.

An appreciation of this symbolic relationship, analogy, or correspondence between the whole and the part, the individual and the nation, opens up to the teacher who yearns for the opportunity of carrying on research work a comparatively new, untilled, almost unexplored region for fascinating investigation. The complexity of the problems to be solved, the great value to humanity of the solutions when scientific, and the magnificent opportunities for self-development, for broadening of the personal outlook and for obtaining a clearer understanding of present conditions all offer alluring inducements to every growing man or woman to take part in this new enterprise. By such labor—painstaking, patient, unprejudiced, in a word, scientific—every one may help in gaining for all a better and more adequate interpretation of the past of our civilization and of the present nature of the individual than any hitherto acquired.

In addition, all such study, leading as it inevitably must do to a deeper insight into the realities of the life of mankind and of man, can not fail to inspire the open-minded and earnestly seeking soul with an ever keener appreciation of the majesty, the mystery and the final beauty of humanity. As Lamprecht, after outlining some of the problems of universal history, fitly says:²

On entering the limitless field of universal history, the speaker feels it incumbent upon him to declare that he does it with the greatest diffidence. Whoever thinks along historical lines and has a fair knowledge of some period of universal history, *e. g.*, of the history of a single nation, will be overcome with a feeling of awe at the prodigious many-sidedness and the endless significance of human activities. And, as a result of this feeling, gentle stirrings of the mind are aroused, which take form in sacred admiration of the achievements of mankind; a noble yet dangerous devotion to the grandeur of the human race takes possession of us. . . . We can not enter into problems of universal history, unless we do it with the earnestness of religious feeling, else the standard of the methods which may be used will be completely obsolete and will consequently fail in the application.

This second point may be most fitly summed up in the words of Froebel:³

Every human being who is attentive to his own development may thus recognize and study in himself the history and the development of the race to

² "What is History?" p. 185.

³ "Education of Man," p. 41.

the point it may have reached, or to any fixed point. For this purpose he should view his own life and that of others at all its stages as a continuous whole, developing in accordance with divine laws. Only in this way can man reach an understanding of history, of the history of human development as well as of himself, the history and phenomena, the events of his own development, the history of his own heart, of his own feelings and thoughts; only in this way can he learn to understand others; only in this way can parents hope to understand their child.

III. Having now defined what sort of history is under discussion, we may now turn to ask what we are to understand by science. This term is generally considered to be synonymous with classified or organized knowledge. But if we confine ourselves to this meaning of the word science, and if we think that we are studying the history of science when we study the gradual accretion of classified knowledge, we shall not be able to get from our labors much illumination on the subject of culture epochs; for in the early stages of civilization, in the ruder culture epochs, we find no classified knowledge that would now be recognized as science—no laws of nature, no great abstract principles. Yet there must have been, in those barbaric and primitive times, something that bore the earmarks of science—something which could serve as a means of identifying the nature of the culture epoch from the point of view of science. What was this, and how discover it? Is there any characteristic of scientific work—any typical factor which always appears in a scientific investigation, and whose rudiments may be discovered even in so-called uncultivated epochs and in apparently scienceless eras?

Recently it has been suggested that the scientific status of a nation at any epoch may be determined from a study of the kind of problems over which the people puzzled and the way in which they solved them, *i. e.*, problem-solving furnishes a criterion of culture from the point of view of science. This criterion is evidently capable of universal application, since every nation and every individual of every nation has had to meet and to solve problems. Furthermore, problem-solving always involves, to a greater or less extent, the use of the creative imagination; hence this criterion justifies itself in the light of the definition of history just given, since the kind of history that is needed has to be studied through the expressions of that imagination.

One thing more is necessary in order completely to define our criterion of scientific culture, and that is a statement of the conditions under which problem-solving may be classed as scientific. It is probably not necessary here to more than state those conditions, since their meaning is now so well understood. A problem has been solved scientifically when its solution has stood the test of the most unprejudiced and relentless criticism both from the side of reason and from that of experiment; and also, when the limits within which its solution is valid

have been determined. The importance of this function of the critical faculty in scientific work is too often overlooked; for it is not always so agreeable to remember that criticism is as fundamental a necessity for creative work as is imagination. Since this interplay between the imaginative and the critical faculties is not so well known as the scientific method, we may say that a problem is solved scientifically when its solution has been obtained by the scientific method.

It is important to notice that this definition of science as problem-solving shifts the emphasis in the scientific work from classified knowledge, which is the result of the process, to the process itself, by which the result is obtained. It must also be noted that this definition is more comprehensive than that of classified knowledge, since it may include the operations of a savage in learning to fish and hunt, as well as work by this method in subjects not ordinarily considered parts of science, like classical philology, higher criticism, philosophy and even commerce and politics—not to mention theology.

This third point may now be summarized as follows: The thing whose history is to be studied under the title of history of science is not classified knowledge, the finished product; but it is problem-solving by the scientific method, that active creative process which involves the properly coordinated use of both the imaginative and the critical faculties.

IV. When we attempt to interpret the history of science in the light of the principles just explained, we are bewildered by the complexity and the magnitude of the task. How may any one ever hope to unravel the tangled mass of material that confronts us, or to bring order out of the apparent chaos of problems which have engaged the attention and taxed the energies of mankind. Consider how intricate and how seemingly inexplicable are the problems that overwhelm each individual: how much greater must be the intricacy and the almost hopeless mystery of the problems that vex an entire nation at any epoch! Fortunately, some progress has been made since the time of Hesiod, who wrote: "In the beginning there existed Chaos," the modern view having been expressed by Chamberlain* in the words: "No. Chaos has always been at home only in the human mind, never elsewhere." Hence, it is no longer allowable to regard the attempt to find a rational interpretation of the history of science as foolhardy.

A good deal of progress has already been made toward the production of a history of science along the lines here indicated, and a number of practically valuable conclusions have already been reached. For example, the recent discussions of the origin of problems is tending to clarify our notions of how science (problem-solving) originates. This is evidently one of the first phenomena demanding interpretation at the

* *Grundlagen des neunzehnten Jahrhunderts*, p. 737.

hands of the historian of science. In this matter the historian of science may be of great assistance to the psychologists among whom the discussions are being carried on; since, because of the analogy of the individual and the nation, the origin of a problem in the one may throw light on the similar process in the other.

This may be illustrated by numerous examples. Thus, some psychologists claim that the problems of science grow out of the practical needs of social and economic life. For example, to the primitive man the problem of catching the fish becomes real and definite because of his hunger. In like manner, the problem of the steam engine developed only after there was urgent need of such a machine for mining purposes; and the problem of the electric telegraph was defined by a marked social demand for a quick method of sending messages. The modern inventor finds the impulse to invention in his hope of gaining material reward for a more efficient machine, etc. But while this explanation of the origin of problems may do for those that fall within the realm of applied science, some think that it is not so useful when applied to the problems of pure science, like that of the motions of the solar system, the phenomena of universal gravitation, etc.

In order to account for the origin of this latter type of problem, it has been claimed that the prime factor in the definition of the problems that go to make up science is not to be found in the practical or concrete external situation, but rather in some internal ideal or desire or feeling with which an individual becomes inspired, he knows not how or whence. According to this view, an individual may notice an external phenomenon over and over again without its defining in him a problem. It is only when he notices in the phenomenon two or more factors that do not seem to him to be in harmony—not to accord with some cherished or imagined ideal—that a state of curiosity or of mental tension is induced; and when this condition is reached, he has a problem defined within him, which, if he have any real scientific spirit, does not suffer him to rest until his curiosity is satisfied or his mental tension eased. When this latter state is reached, he is said to have found an "explanation," and the problem is for him solved.

These statements are, of course, but the crudest possible descriptions of but two of the points of view from which the origin of problems has been approached. It will require considerable discussion and study before the whole matter will be cleared up in a tolerably satisfactory manner. But even though the question is far from settled, two important conclusions follow at once from either or both of the points of view just outlined. The first is this: Science is not the source of the progress of civilization. It is rather the faithful handmaid who helps us truly to satisfy the practical needs of society as they become manifest, and to achieve the purposes, ideals, or whatever they are, that

spring up within us somehow to disturb our peace of mind. In other words, scientific problems, and therefore science, originate in either the external situations of concrete experience, or in our ideals, or in both, and hence these latter and not the former are the real source of progress. Thus progress is simply a process of self-realization of society, and science is a powerful tool for the successful carrying on of the process.

The other important conclusion applies to the teaching of science, and it is too patent to need more than statement. It is this: Science in the individual child arises, as it has in society, from either the outer surroundings or the inner purposes of the child. Unless the problem whose partial solution we wish to teach the child spring up within him from either outer or inner necessity, the problem is not his own problem, it is not real to him, and, therefore, its solution is not real to him and so makes no impression. Hence the skill in teaching science is a skill in presenting facts in such a way that the problems whose solutions we wish to teach become the child's own problems. It is thus a skill in causing problems to become defined in the child's mind. The science of the child, like the science of humanity, consists, then, in his own solving of problems that seem to him to arise naturally, either out of his own practical necessities of his own social and economic life, or out of his own purposes, ideals or aspirations that seem to him to have sprung up spontaneously within him. This sort of teaching is quite a different matter from that which generally passes under the name of science teaching, namely, learning the laws and principles of science from a book by memory, with some laboratory and lecture experiments thrown in gratis by way of illustration.

V. So much for the light thrown on present conditions by the study of the origin of scientific problems. But one other example will be added to show the sort of interpretations that may be reached through a study of the way in which various peoples have used their creative imaginations in solving their problems after they had once become defined. For this purpose a problem in applied science will be more illuminating, so we will take this: How was the problem of satisfying the human need of worship solved by the Greeks and by the people of the middle ages? Both expressed their solutions in concrete form in buildings, which still stand as permanent expressions of the workings of their respective creative imaginations.

The Greek temple was a larger and somewhat idealized man's dwelling—a home for deified men and women. It was limited in design to straight lines, since the idea of a curved arch had not yet been achieved in practise. Yet it was a perfect realization of the conception which it was intended to embody—a limited conception, since the idea of deity which makes God to consist of heroic or idealized men and women must

necessarily be cramped and limited. The Greek temple was not intended for public worship of an invisible God, but for the actual residence of their many humanized gods. From this it may appear that their religion was man-made, *i. e.*, that it was no real religion, but only a philosophy; and so we are in a better position to comprehend the classical ancestor worship and the Lares and Penates. When we start from this center we may also get a better insight into the Greek character as a whole.

The middle-age cathedral, on the other hand, bore no resemblance to the dwellings of men. It was a lofty edifice with numerous spires pointing to heaven. It was built for public worship of one God, and was adorned at every point with a richness of tracery and design that would bewilder the observer of to-day were it not so harmonious in all its parts. The conceptions embodied in it are wholly distinct from those ultimated in the Greek temple, showing what a complete and fundamental change in the idea of divinity had come over mankind. The cathedral was not the perfect realization of a limited ideal, but the imperfect realization of an unlimited ideal; and this shows a vast expansion and elevation of the conception of religion—an expansion and elevation that must be ascribed wholly to the christian religion.

Furthermore, the effort to realize these expanded and elevated ideals led to the definition and the solution of numerous practical problems in applied science. The construction of a Greek temple is a simple engineering feat when compared with that of a Gothic cathedral. The solution of these engineering problems lead to the definition of others; and so we see in the middle ages a great development of skill in all sorts of manual arts, carving, metal working, stone cutting, weaving, printing, etc., all before modern science made any pretense of being extant.

Time forbids the following of the argument into detail. There are just two important conclusions that seem to be justified by this comparative study. I will, in closing, state them; and leave the reader to find out if, after further study, he too finds them justified. The first is this: Since Christianity was the source of the ideals that led to the construction of the cathedrals; and since this work and these ideals led to the definition and solution of many problems in applied science; and since the solution of problems in applied science precedes and prepares the way for the definition of problems in pure science; therefore, we may make the hypothesis, subject to further verification, that modern science owes its origin from the side of the imagination to Christianity. Hence the so-called warfare of science and religion is but a sham battle between science and dogmatic theology—between reason and unreason. Modern science is, from this point of view, really the child of Christianity.

The second conclusion that seems justified is no less important for the science teacher. It is this: Since the dawn of modern science was preceded by the solution of a great number of practical problems, which arose from the practical needs and the ideals of the times, and which developed in humanity a great deal of skill in the handling of tools and the mastering of matter, the course of the child in learning science should be similar. Hence, it is unscientific to try to teach modern science to a child that has not been prepared for it by a symbolic middle-age training in the mastery of tools, brute force and concrete matter.

No one can realize more fully than the writer the inadequacy of this discussion of this mighty theme. The same theme has been handled far more completely by Carlyle in the following short paragraphs from his review of the *Corn Law Rhymes*:

Nay, it appears to us as if in this humble Chant of the Village Patriarch might be traced rudiments of a truly great idea; great though all undeveloped. The Rhapsody of "Enoch Wray" is, in its nature and unconscious tendency, Epic; a whole world lies shadowed in it. What we might call an inarticulate, half-audible Epic! The main figure is a blind aged man; himself a ruin, and encircled with the ruin of a whole Era. Sad and great does that image of a universal Dissolution hover visible as a poetic background. Good old Enoch! He could *do* so much; was so wise, so valiant. No Ilion had he destroyed; yet somewhat he had built up: where the Mill stands noisy by its cataract, making corn into bread for men, it was Enoch that reared it, and made the rude rocks to send it water; where the mountain Torrent now boils in vain, and is mere passing music to the traveler, it was Enoch's cunning that spanned it with that strong Arch, grim, time-defying. Where Enoch's hand or mind has been, Disorder has become Order; Chaos has receded some little handbreadth, had to give up some new handbreadth of his ancient realm. . . .

Rudiments of an Epic, we say; and of the true Epic of our Time,—were the genius but arrived that could sing it! Not "Arms and the Man"; "Tools and the Man," that were now our Epic. What indeed are tools, from the Hammer and Plummot of Enoch Wray to this Pen we now write with, but Arms, wherewith to do battle against UNREASON without or within, and smite in pieces not miserable fellow men, but the Arch-Enemy that makes us all miserable; henceforth the only legitimate battle!